A new Design of the RFQ-Decelerator for HITRAP

S. Yaramyshev, W. Barth, G. Clemente, F. Herfurth, M. Maier, H. Vormann

GSI, Darmstadt, Germany

Introduction

The HITRAP linear decelerator at GSI is designed to slow down heavy ions for experiments with ion traps [1]. During experimental campaigns the deceleration from 4 MeV/u to approx. 500 keV/u (design value) with an IH-DTL structure was demonstrated, while behind the HITRAP-RFQ no particles with design energy of 6 keV/u were observed.

Dedicated beam dynamics simulations with DYNAMION code for the old HITRAP-RFQ, based on 3D-fotometrie of the fabricated RFQ electrodes, demonstrated a significantly higher required input beam energy around 525 keV/u instead of the design value of 500 keV/u. The energy offset was experimentally confirmed at the test stand at MPI-K (Heidelberg). The mismatch of the RFQ acceptance to the design energy is the most probable explanation for not observing deceleration of the beam to energy of 6 keV/u at HITRAP facility [2].

The new RFQ decelerating-focusing channel was designed to reach the following main goals:

- correct RFQ input energy;
- increased longitudinal acceptance;
- low cost by use of the existing tank;
- improved alignment of electrodes using new mechanical design [3].

The new RFQ decelerating-focusing channel was designed with the interactive object-oriented code DESRFQ [4]. Dedicated features of the code provide for a detailed cell-by-cell design. A screenshot, which illustrates the final stage of a design process, is shown in Fig.1. A cross-check of the beam dynamics was made with DYNAMION package, which also comprises the built-in routines for reliable calculation of external electrical field on the base of real geometry of the electrodes and tank.

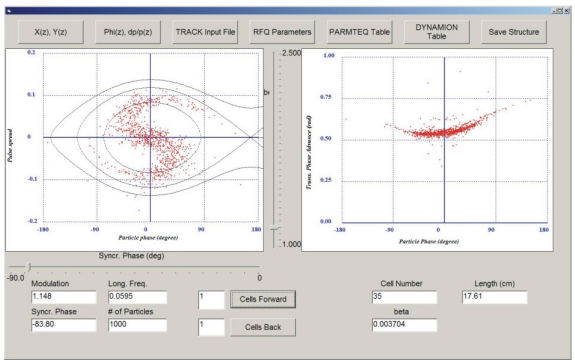

Figure 1: Typical screenshot from the code DESRFQ: beam portrait on longitudinal phase space (left) and stability diagram (right).

The new RFQ electrodes were designed with the same length as the old ones. New laws of modulation and synchronous phase provide for the correct input energy as well as for almost constant electrical field strength on the electrode surface, significantly lower than for the old RFQ, even in spite of 15% higher RFQ voltage between adjacent electrodes. This allows for higher focusing as well as for lower modulation (enlarged aperture). Both effects improve a transverse acceptance of an RFQ.

Improved longitudinal RFQ acceptance

Calculations of the old and new channel acceptances were performed with wide distribution of input particles in 6D phase space. The particles decelerated below 7 keV/u and filling the acceptance at the RFQ entrance, are shown on Fig. 2. The longitudinal acceptance for the new channel is about twice as high as the old one. The transverse acceptance is some percent lower due to the strong coupling between transverse and longitudinal properties of the RFQ. Nevertheless the total 6D acceptance for the new design is significantly higher.

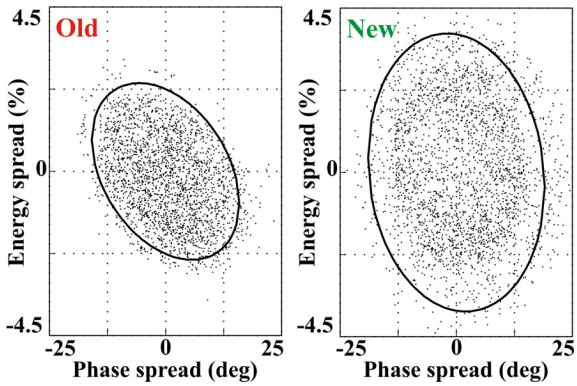

Figure 2: Particle distribution representing the longitudinal RFQ acceptance for old (left) and new (right) designs. The ellipses describe 90% of the particles.

Conclusion and outlook

The new HITRAP-RFQ has been designed, fabricated and assembled at GSI and successfully commissioned off-site at MPI-K [5]. Main goals of the design - correct input energy and about twice higher longitudinal acceptance - have been reached. Commissioning of the GSI HITRAP facility with the new RFQ is planned for 2013.

References

[1] F. Herfurth et al., HIAT-12, Chicago, 2012
[2] S. Yaramyshev et al., LINAC-12, Tel-Aviv, 2012
[3] K. Dermati et al., this Annual Report
[4] S. Yaramyshev, HB-10, Morschach, 2010
[5] M. Maier et al., this Annual Report